Introduction to EVN data

Joe Callingham (ASTRON)

Kenyan Radio Astronomy School,
Nairobi, Kenya
29th of May 2018

DARA
DEVELOPMENT IN AFRICA WITH RADIO ASTRONOMY

UNIVERSITY OF LEEDS

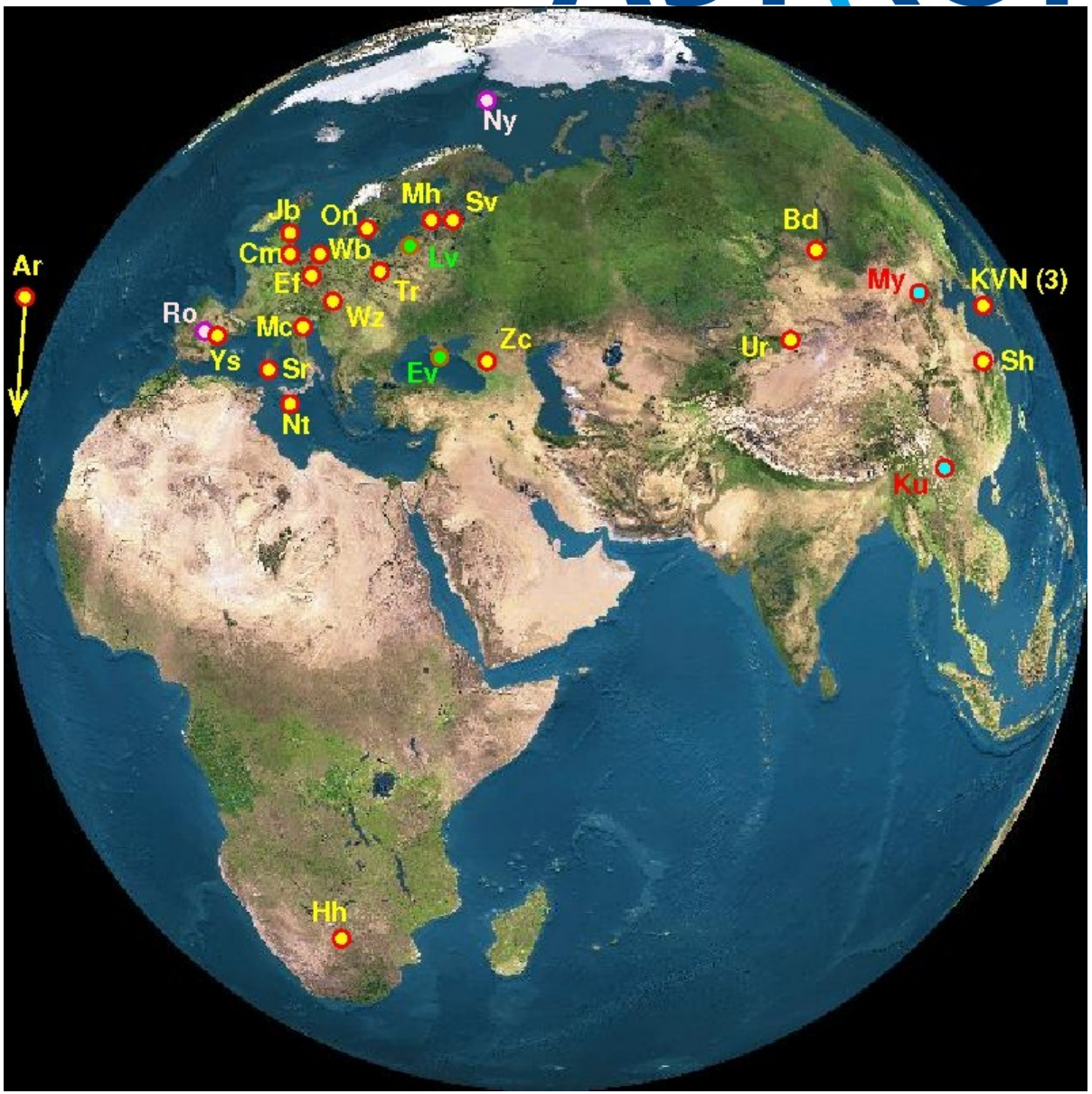
VLBI

ASTRON

EVN made of

EVN

- Ad-hoc array of about ten regular members (can be up to
- Largest regular member 100-m Effelsberg. Smallest <20m
- Phased arrays e.g. WSRT also have large effective areas



Data Transport

ASTRON

- Most data recorded at each telescope onto computer disk packs (originally, tapes)
- Shipped to JIVE correlator, The Netherlands
- Now it is possible to get all the data over the internet in select cases

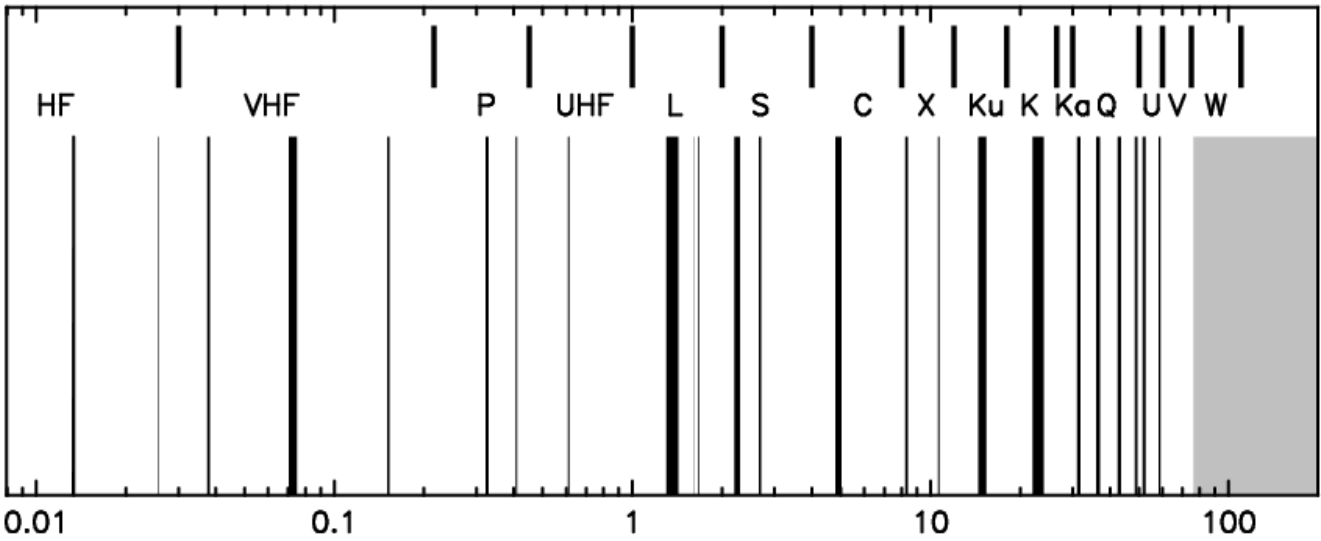
Notes of warning!

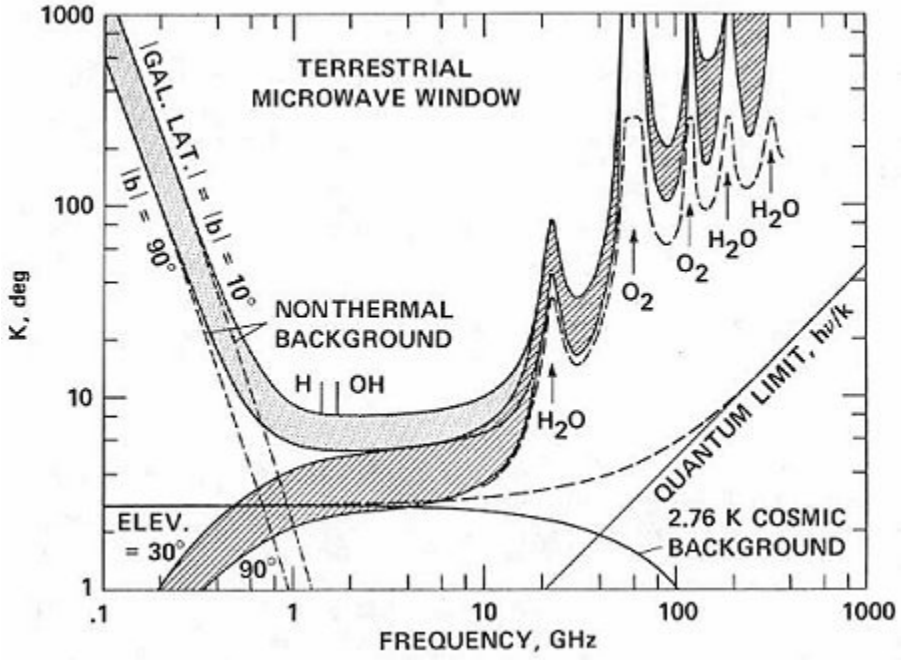
ASTRON

- The EVN has great collecting area for a VLBI instrument but it is an ad hoc array
- You have to reconnect the puzzle in just the right way (especially for polarization)

The observations – n14c3

- Observed (gain calibrator, phase calibrator, and source) 2014 Oct 22 in C-band (~5 GHz)
- Sweet spot for VLBI as receivers are sensitive, sky noise is low, and limited impact from atmosphere

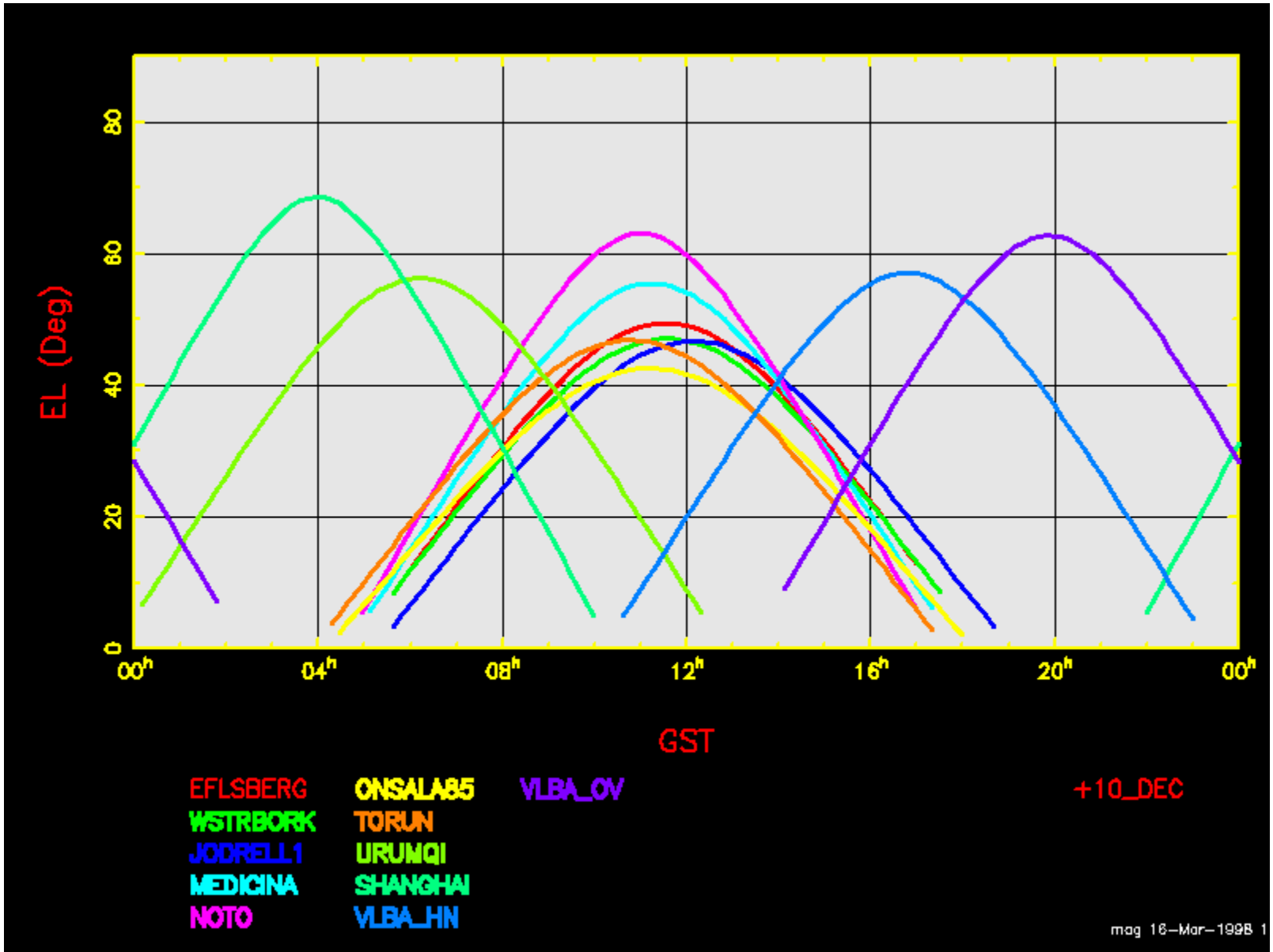




(Simple) Calibration Strategy

1. Observe bright source with known flux density for gain calibration
2. Go to phase calibrator (reasonably bright – usually ~100 mJy at least)
3. Go to source (which might be too faint to observe in real time)
4. Back to phase calibrator (time set by frequency, observing conditions, etc)
5. Repeat 3 and 4 until reach desired noise floor
6. Usually finish on Gain cal.

Remember all telescopes need to see sources!



Observations

EVN OBSERVATORIES	TELESCOPE		
	Code		Diameter(m)
Jodrell Bank (UK)	Jb-1	Lovell	76
	Jb-2	Mk2	25
Cambridge (UK)	Cm		32
Westerbork (NL)	Wb		25
Effelsberg (DE)	Ef/Eb		100
Medicina (IT)	Mc		32
Noto (IT)	Nt		32
Sardinia (IT)	Sr		65
Onsala (SE)	On-85		25
	On-60		20
Sheshan(Shanghai,CN)	Sh		25
Tianma(Shanghai,CN)	Tm65 (T6)		65
Nanshan(Urumqi,CN)	Ur		25
Torun (PL)	Tr		32
Metsaehovi (FI)	Mh		14
Wettzell (DE)	Wz		20
Svetloe (RU)	Sv		32
Zelenchukskaya (RU)	Zc		32
Badary (RU)	Bd		32

- 12 antennas used
- Data recorded on disc
- Data correlated at JIVE and stored in FITS IDI format
- Tsys measurements recorded separately
  - Gain elevation curves also recorded

$$T_{sys} = T_{cmb} + \Delta T_{source} + T_{atm} + T_{spillover} + T_{rcvr} + \ldots$$

Summary of observation status

ASTRON

Network Monitoring Report: **C-band** N14C3

Source: 3C345, 1848+283, 2023+336, J1640+3946, J1849+3024
Reference antenna: Effelsberg
Experiment code: N14C3

Length: 180 min.
Date of observations: 22/10/14
Date of report: 28/01/15

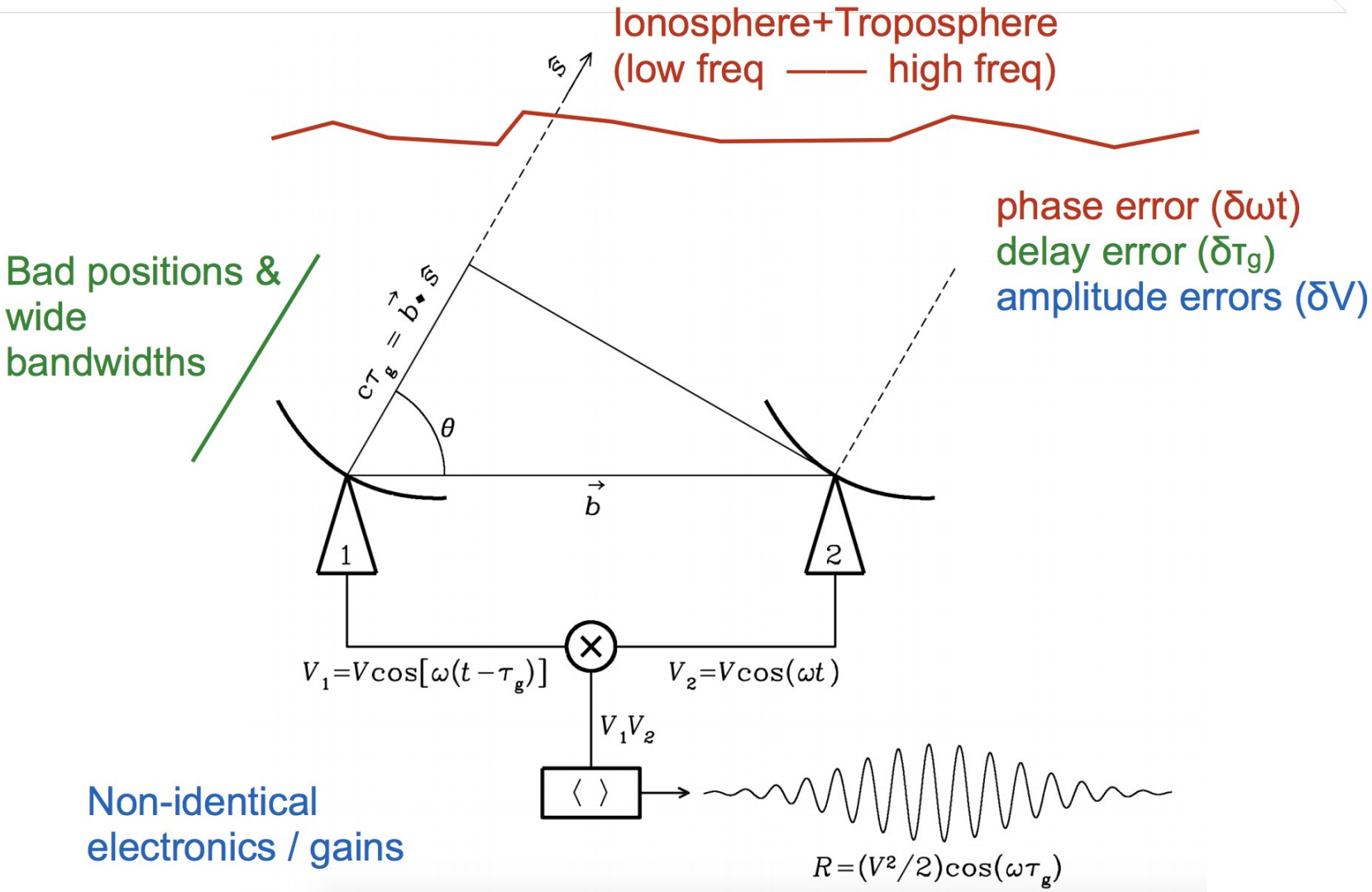
Observing mode: Mk V, mode 512-8-2, dual pol.
Reference date: 22/10/14; 295d 12h 00m
by: Gabriele Surcis

⊗ According to expectation, no special remarks
■ Problem occured - see enclosed footnote(s)
⬚ Station did not observe (not scheduled)
○ Entry not applicable/investigated

	Ef	Wb	Jb	On	Nt	Tr	Ys	Sv	Bd	Zc	Sh	Hh
Station has observed	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Station produced fringes (ftp)	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Station produced fringes (disk)	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Filled in TRACK	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Logs are available (within 72 hours)	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
GPS data available (within 7 days)	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Disks are available (within 7 days)	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Feedback on www (within 7 days)	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
GPS clock estimate gives fringes	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Clock offset in μsec	−23.511	1.333	−6.779	9.665	−9.222	171.560	7.984	215.926	215.730	213.622	25.426	4.091
Clock rate in psec/sec	−0.139	0.174	0.086	0.105	0.080	−18.000	0.428	0	0	0	0.773	0.181
Recording okay	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Polarization setup okay	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Strong signal amplitude	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Phase cal aligns phases	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Sampler statistics okay	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Please check VC number(s):												
Previous reported problem(s) corrected												
Problem(s) first reported												
See enclosed footnote(s):								a				

Enclosure: Footnotes C-band N14C3

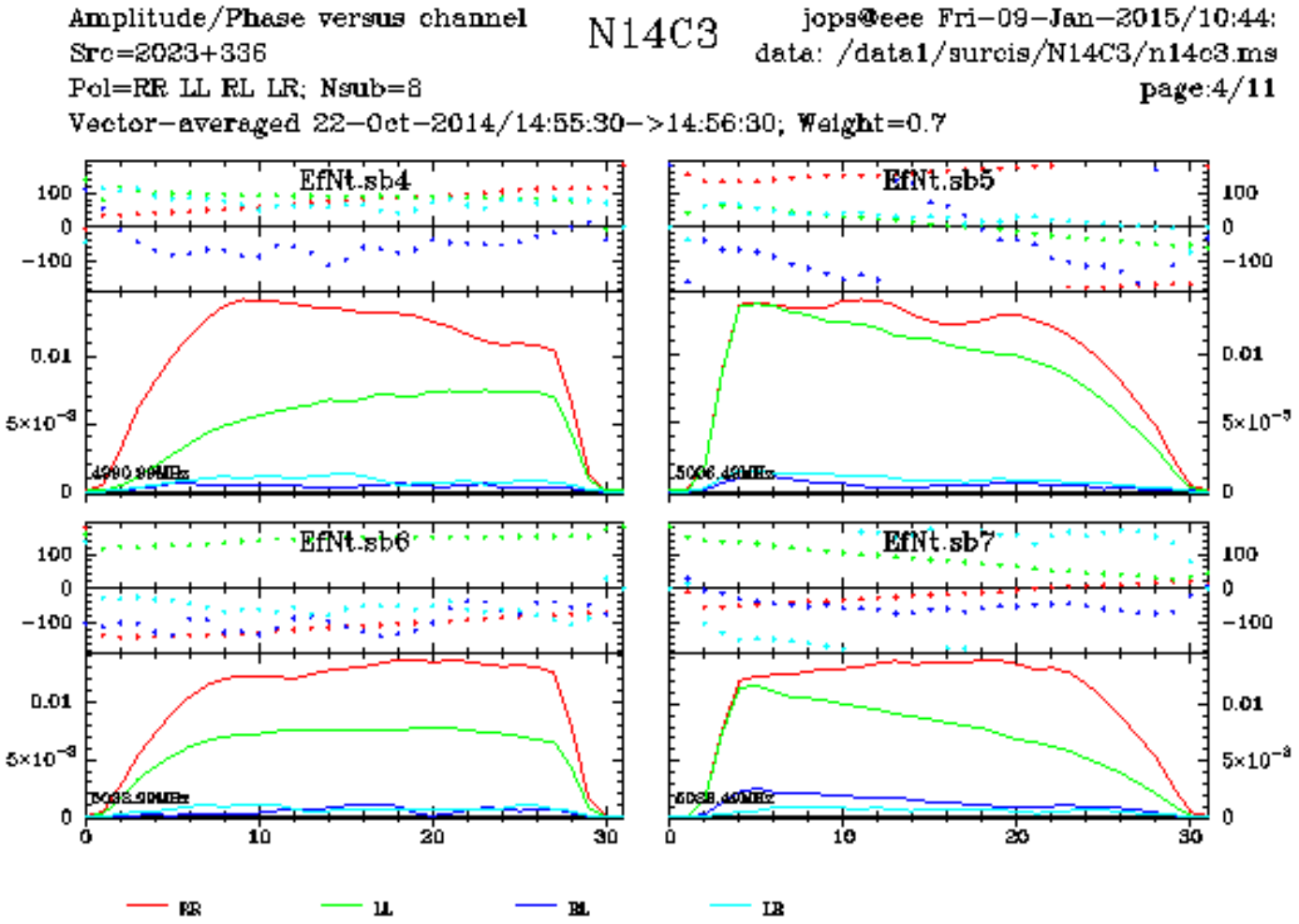
Calibration is to fix this mess…



Solve for these issues using calibration

Delay (phase v. frequency)

- Correlated data have residual timing errors
- These data are pretty good!
- Very important to correct before averaging (otherwise decorrelate)



Manual processing of n14c3

ASTRON

- Apply T_{sys} and gain-elevation corrections
  - Provides approximate flux scale by using SEFDs
    - (emission in Jy equivalent to system temperature)
- Inspect brightest compact source in data (BP cal)
- Select ~2 min good data to derive delay corrections
  - Short period to avoid time-variable decorrelation
  - Assume clock errors constant, apply correction to all data
- Iteratively correct phase and amp v. time and freq to derive a bandpass correction table, apply to all data

Manual processing of n14c3

ASTRON

- At several stages:
  - In each calibration step, apply parallactic angle correction, i.e. compensate for different effects on L and R feeds as Alt-Az antennas rotate on the sky
  - Flag brightest source first, flag other sources as calibration is applied (easier to see bad data)
  - Check amplitude v. uv distance for signs of resolution
- Split out each phase-ref – target pair
  - Bandpass amplitude and phase are calibrated to allow averaging of all channels
  - Calibrate phase reference source phase assuming a point model

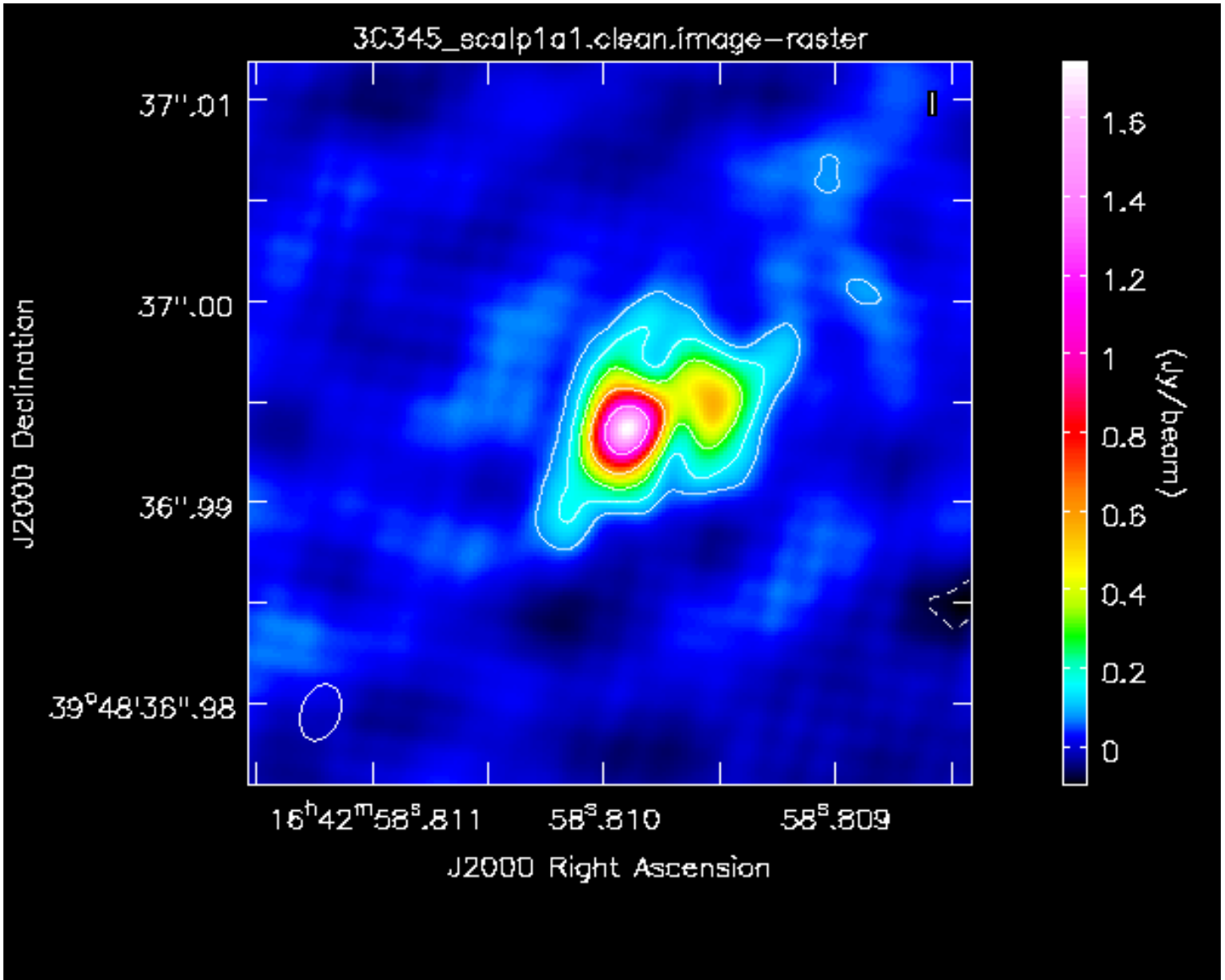
Manual processing of n14c3

ASTRON

- Apply calibration to phase ref and image
- Use image CC as model for phase & amp calibration of phase-reference
  - If very resolved, repeat until good model is achieved
- Apply phase and amplitude solutions derived from the phase ref to the target
  - (bandpass solutions already applied)
- Image target
  - Self calibrate target if bright enough
- Do some science! (in the real world)

The result

› n14c3 image of 3C345



› Thanks to Anita